Suppression of House Flies (Diptera: Muscidae) in Florida Poultry Houses by Sustained Releases of *Muscidifurax raptorellus* and *Spalangia cameroni* (Hymenoptera: Pteromalidae)

CHRISTOPHER J. GEDEN[1] AND JEROME A. HOGSETTE

USDA–ARS, Center for Medical, Agricultural and Veterinary Entomology, PO Box 14565, Gainesville, FL 32607

Environ. Entomol. 35(1): 75–82 (2006)

ABSTRACT Weekly releases of *Muscidifurax raptorellus* Kogan and Legner and *Spalangia cameroni* Perkins were made for 12 wk after house cleanouts in Florida pullet houses in either spring/summer (May–August) or fall (September–December). Releases were made by weekly placement of 62,500 and 85,000 pupae parasitized by *M. raptorellus* and *S. cameroni*, respectively, which produced an average of 79,049 and 32,841 adult female parasitoids per week. House fly (*Musca domestica* L.) pupal mortality, as measured by sentinel pupae, was about twice as high in the release house (40.2%) as in the two control houses (21.5 and 21.8%) in the summer release. Pupal mortality in the fall was three to four times higher in the release house (45.6%) as in the two control houses (13.6 and 8.4%). Although successful parasitism of sentinel pupae was only ≈8.4% in the release houses in both studies, parasitism was significantly higher than the control houses in both summer (3.9 and 1.7%) and fall (0.0 and 0.8%) releases. Fly populations were high in both studies but significantly lower in the release houses than the controls in both summer (361.5 versus 450.3 and 584.4 spots/spot card/wk) and fall (477.1 versus 971.4 and 851.8 spots/card/wk) releases. An average of 4.8 *M. raptorellus* emerged from each pupa parasitized by this species, with parasite loads ranging from 1 (8.6%) to 17 (0.07%) adults emerged per parasitized pupa.

KEY WORDS *Muscidifurax raptorellus*, *Spalangia cameroni*, house fly, biological control, poultry

PUPAL PARASITOIDS IN THE family Pteromalidae are among the most naturally abundant biological control agents of house flies (Rutz and Patterson 1990). Releases of parasitoids, especially when combined with other integrated pest management (IPM) components, can increase rates of parasitism to levels that provide an adequate degree of fly control (Morgan and Patterson 1990, Geden et al. 1992, Petersen and Cawthra 1995, Crespo et al. 1998, Skovgard and Nachman 2005). In other instances, parasitoid releases have had little impact on fly populations or parasitism levels (Meyer et al. 1990, Andress and Campbell 1994, Weinzierl and Jones 1998, McKay and Galloway 1999, Kaufman et al. 2001a).

The choice of which species to deploy in parasitoid releases is often based on practical considerations (is the species available in sufficient quantities?) and local surveys of natural parasitism in the target ecosystem, on the assumption that the most abundant species is probably best adapted to the target system. Some of the previous work using this approach was conducted using *Spalangia endius* in Florida, *Muscidifurax raptor* in New York, and *Spalangia nigroaenea* in Illinois (Morgan and Patterson 1990, Geden et al. 1992, Weinzierl and Jones 1998).

[1] Corresponding author, e-mail: cgeden@gainesville.usda.ufl.edu.

In recent years, encouraging results have also been obtained with *Spalangia cameroni* (Denmark) and the gregarious species *Muscidifurax raptorellus* (Nebraska, New York, Alberta) (Petersen and Cawthra 1995, Floate et al. 2000, Kaufman et al. 2001b, Skovgard and Nachman 2005). *Spalangia* and *Muscidifurax* spp. complement one another in a number of ways, including attack rates, responses to temperature, and the types and depths of habitats in which they forage for pupae (Geden 1996, 1997, 1999, 2002, King 1997, Lysyk 2001). Because of this, Rueda and Axtell (1985) suggested that combined releases of both genera might be more effective than single species releases. The objective of this study was to evaluate combined releases of *S. cameroni* and *M. raptorellus* against house flies in Florida poultry houses.

Materials and Methods

Tests were conducted on two commercial laying-hen pullet farms (designated A and B) located near Brooker, FL. Both farms had two 152- by 14-m high-rise houses with ≈100,000 caged birds that were held for 16- to 18-wk growth cycles, with 2- to 6-wk intervals between flocks for bird removal, manure cleanout, and maintenance.

Table 1. Estimated release rates of *M. raptorellus* and *S. cameroni* based on emergence of subsamples held in the laboratory (*N* = 24 batches of each species)

Species	No. pupae placed per week	Percent pupae parasitized	Percent females	No. parasitoids per pupa	No. females released per week
M. raptorellus	62,500	59.1 (5.1)	44.5 (1.2)	4.81 (0.19)	79,049
S. camereoni	85,000	57.3 (4.4)	67.4 (1.7)	—	32,841

Parasitoid releases were made during two flock growth cycles, with the first (spring/summer) beginning on 6 May 1998 and the second (fall) beginning on 23 September 1998. During each release, parasitoids were released in one of the two houses on farm A. Two control houses were included in each test; the second house on farm A and one of the houses on farm B. In the second (fall) test, the treatment assignments (release and control) were reversed for the two houses on farm A. During the second test, we were unable to collect samples from the control house farm B on weeks 4–10 because flooding made the road impassable for our vehicle. Only one house from farm B was used in the tests because its flock cycle was in closer synchrony with the two houses on farm A (the second farm B house was ≈9 wk out of synchrony with the other three houses).

Releases were made weekly for 12 wk after the first week of manure accumulation by placing 62,500 and 85,000 pupae parasitized by *M. raptorellus* and *S. cameroni*, respectively, each week. These rates were used because it was anticipated that they would provide ≈50,000 pupae from which adults of each species would emerge. Parasitized pupae were deployed in the manure pit in 10 release stations consisting of 2-liter plastic containers covered with metal screening to protect the pupae from rodents. Samples of 100 pupae parasitized by each species were placed individually in gelatin capsules to determine parasitism and sex ratios of pupae in each weekly release batch. Parasitized pupae were obtained from Beneficial Insectary, Oak Run, CA.

Parasitism was monitored by weekly placement of 10 mesh bags of 50 1-d-old laboratory-reared house fly pupae (sentinel pupae) (Rutz and Axtell 1979) in areas of observed or likely fly activity in each house. Pupal bags were replaced 1 wk later, and the exposed pupae were returned to the laboratory, placed in gelatin capsules, and held for fly and parasitoid emergence at 27°C, 70% RH, and a 16:8 (L:D)-h photoperiod. Because of the difficulty in distinguishing between *M. raptorellus* and *M. raptor* using morphological features (*M. zaraptor* were not found in this study), any solitary parasitism by *Muscidifurax* spp. was assumed to be caused by *M. raptor.* The relative abundance of parasitoid species was calculated as the percentage of total parasitized pupae that were parasitized by each species. The sum of the relative abundance of *M. raptorellus* and *S. cameroni* was used an indicator of the effect of the releases. Fly activity was monitored by counting fly fecal and vomit spots deposited on 20 white index cards (7.6 by 12.7 cm) located in the manure pit of each house. Cards were replaced weekly.

Data were analyzed by averaging the 10 bags (or spot cards) from each house per week and using this value as a single replicate; weeks since bird placement (n = 16–18) were treated as replicates rather than calendar dates because bird placement dates in the three houses varied by up to 5 wk. Percent pupal mortality, successful parasitism (the percent of placed pupae from which adult parasitoids emerged), and relative abundance were subjected to arcsine transformation before analysis. Mortality, parasitism, relative abundance (*S. cameroni* + *M. raptorellus*), and spot card data were analyzed by separate one-way analysis of variance (ANOVA) for each test using treatment (release, control 1, control 2) as the grouping variable using the GLM procedure of the Statistical Analysis System (SAS Institute 1995). Treatment effects were evaluated by single degree of freedom orthogonal contrasts to compare differences between the two control houses and between the release houses and the two controls by using the contrast statement within the GLM procedure.

Results

Successful parasitism of the shipped parasitoids varied from one batch to another, ranging from 6 to 86% for *M. raptorellus* and 6 to 87% for *S. cameroni;* mean parasitism for these species was 59.1 and 57.3%, respectively (Table 1). Of the emerged parasitoids, 44.5% of the *M. raptorellus* and 67.1% of the *S. cameroni* were females, for a calculated estimate of 70,000 and 32,841 females released per week of each species, respectively. An average of 4.8 *M. raptorellus* emerged from each pupa parasitized by this species, with parasite loads ranging from 1 (8.6% of the total 1,420 pupae examined) to 17 (0.07%) adults emerged per parasitized pupa (Fig. 1).

In the first test, conducted mostly during the summer, house fly pupal mortality was about twice as high in the release house (40.2%) as in the two controls (both ≈22%), with no significant difference between the two controls (Table 1). Successful parasitism in the release house averaged 8.4%, which was significantly higher than was observed in either of the controls (3.9 and 1.7%). Fly abundance in the release house was significantly lower (361.5 spots/card/wk) than in the controls (450.3 and 584.4 spots/card/wk).

Pupal mortality in the second test (fall months) in the release house averaged 45.6%, which was significantly higher than in the two controls (13.6 and 8.4%; Table 2). Successful parasitism in the release house in the second test was similar to that observed in the previous test (8.3%); however, parasitism in the two controls was very low. No parasitism at all was ob-

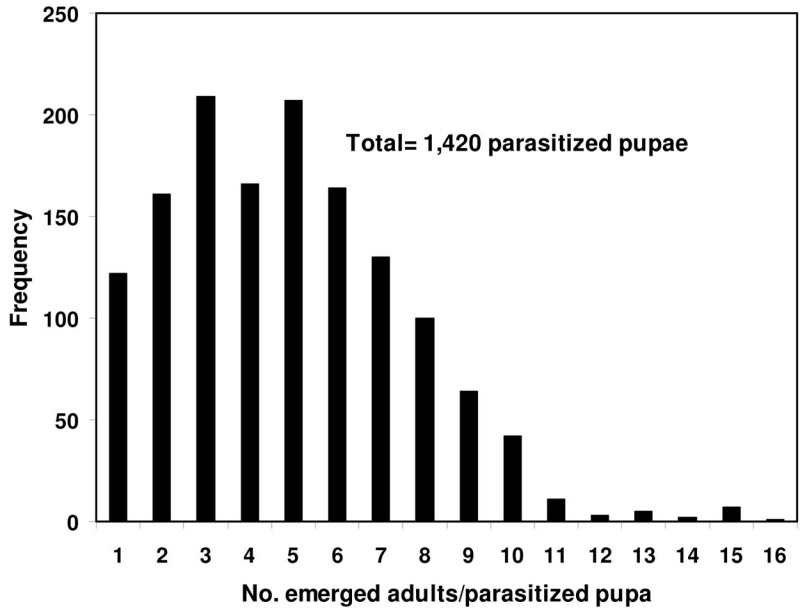

Fig. 1. Distribution of parasitoid load (number of adults emerged/parasitized pupa) in house fly pupae parasitized by *M. raptorellus.*

served in one of the control houses, and <1% was observed in the other. Fly counts, although high overall, were significantly lower in the release house (477.1 spots/card/wk) than in the controls (971.4 and 851.8 spots/card/wk).

Weekly pupal mortality data indicate that in the summer test the effects of the releases were small (<20% mortality) until week 7, after which mortality generally ranged from 40 to 80% (Fig. 2). In contrast, mortality in the release house during the second (fall) test was high (60%) by week 3 and varied comparatively little throughout the test. Successful parasitism in the release house during the first test peaked at 23% on week 7, whereas parasitism in the control houses was low (<5%) until week 13 (early September; Fig. 3). Successful parasitism in the second test was negligible or absent in the control houses throughout the study and only exceeded 10% in the release house on weeks 3–4 and 6–8.

Table 2. Mean (SE) mortality and parasitism of sentinel pupae and rates of fly spotting on control pullet farms and on farms where releases of *S. cameroni* and *M. raptorellus* were made during the first 12 wk after cleanout and new bird placement

Treatment	Percent pupal mortality	Percent successful parasitism	Fly spots/card/wk
Test 1—spring/summer			
Control 1	21.5 (1.9)	3.9 (0.9)	450.3 (57.3)
Control 2	21.8 (1.6)	1.7 (0.5)	584.4 (45.0)
Release	40.2 (2.7)	8.4 (1.2)	361.5 (35.3)
ANOVA *F*			
Overall	25.18[a]	15.33[a]	5.48[a]
Release versus controls	50.36[a]	26.85[a]	6.81[a]
Between controls	0.01[c]	3.49[c]	4.13[b]
Test 2—fall			
Control 1	13.6 (1.3)	0.8 (0.4)	971.4 (69.1)
Control 2	8.4 (1.1)	0.0 (0.0)	851.8 (75.2)
Release	45.6 (2.4)	8.3 (1.3)	477.1 (43.6)
ANOVA *F*			
Overall	107.84[a]	22.34[a]	20.77[a]
Release versus controls	213.57[a]	43.78[a]	33.46[a]
Between controls	2.79[c]	0.27[c]	1.35[b]

[a] $P \leq 0.01$; [b] $P \leq 0.05$; [c] $P \geq 0.05$ (Proc GLM of SAS).

Fly activity in the release house in the first test increased rapidly during the first 6 wk, reaching nearly 1,100 spots/card and then crashed and remained <200 spots/card for the remainder of the test (Fig. 4). Fly populations in the control houses also increased during the first 6 wk and then declined; in one of the control houses, there was a resurgence of fly activity in weeks 11–17. Fly activity in the release house during the second test increased until week 7, peaking at ≈1,100 spots/card/wk and then declined and remained <300 for most of the rest of the test. Fly populations in one of the control houses peaked at nearly 2,000 spots/card at week 6 and exceeded 500 spots/card during most of the weeks after week 4. On the second control farm, we were missing observations during several of the test weeks because of flooding, but fly populations exceeded 500 spots/card on the weeks when collections were made.

Examination of relative abundance of parasitoid species indicated that the two released species comprised ≈74% of the parasitized pupae in the release houses in both tests, with parasitism by *S. cameroni* exceeding that by *M. raptorellus* (Table 3). In contrast, these two species comprised significantly fewer (38–51%) of the parasitoids in the control houses—nearly all because of parasitism by *S. cameroni.* In the control houses, the most abundant species was *S. cameroni*, followed by *S. endius* and *M. raptor.* Other species

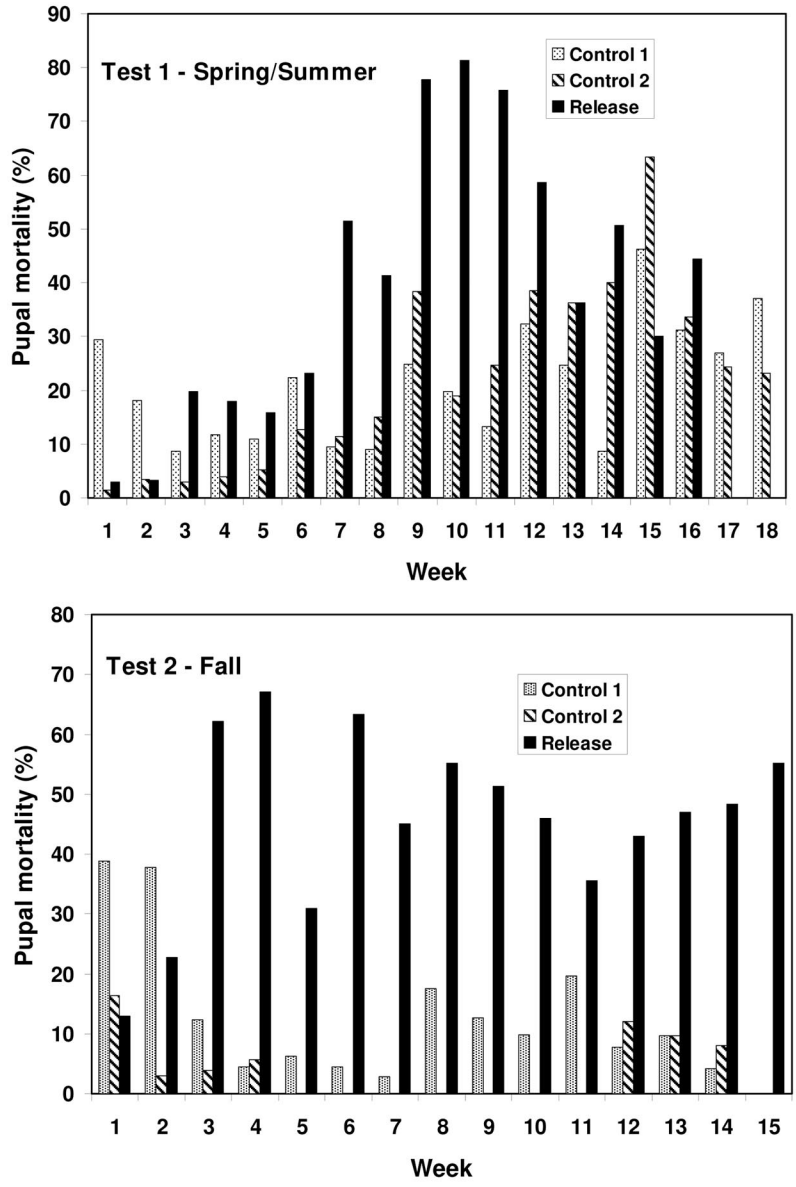

Fig. 2. Weekly mortality of sentinel pupae in control pullet houses and in houses where *M. raptorellus* and *S. cameroni* were released. during the first 12 wk of the flock growth cycle.

recovered included *Nasonia vitripennis* and *S. nigroaenea.*

Discussion

Muscidifurax raptorellus is an attractive biological control agent of filth flies for several reasons. It is a gregarious parasitoid that is easy to rear, has high fecundity, has a short development time, and attacks pupae near the surface and edges of breeding sites where most pupae are located (Lysyk 2001, Geden 2002). It also appears to disperse well away from release sites in cattle feedlots (Petersen and Cawthra 1995, Floate et al. 2000), although Tobin and Pitts (1999) observed only short range movement in poultry houses. In contrast, *S. cameroni* is highly effective at locating buried pupae (King 1997, Geden 2002), and its lower daily attack rate is compensated for by a longevity that is about double that of *Muscidifurax* spp. (Morgan et al. 1989, Lysyk 2001).

Because both *M. raptorellus* and *S. cameroni* have proven effective in single-species releases in some cases, we felt that a combined-species release was worth evaluating. In this test, most of the successful parasitism observed in the release houses was caused by *S. cameroni.* This was surprising for two reasons.

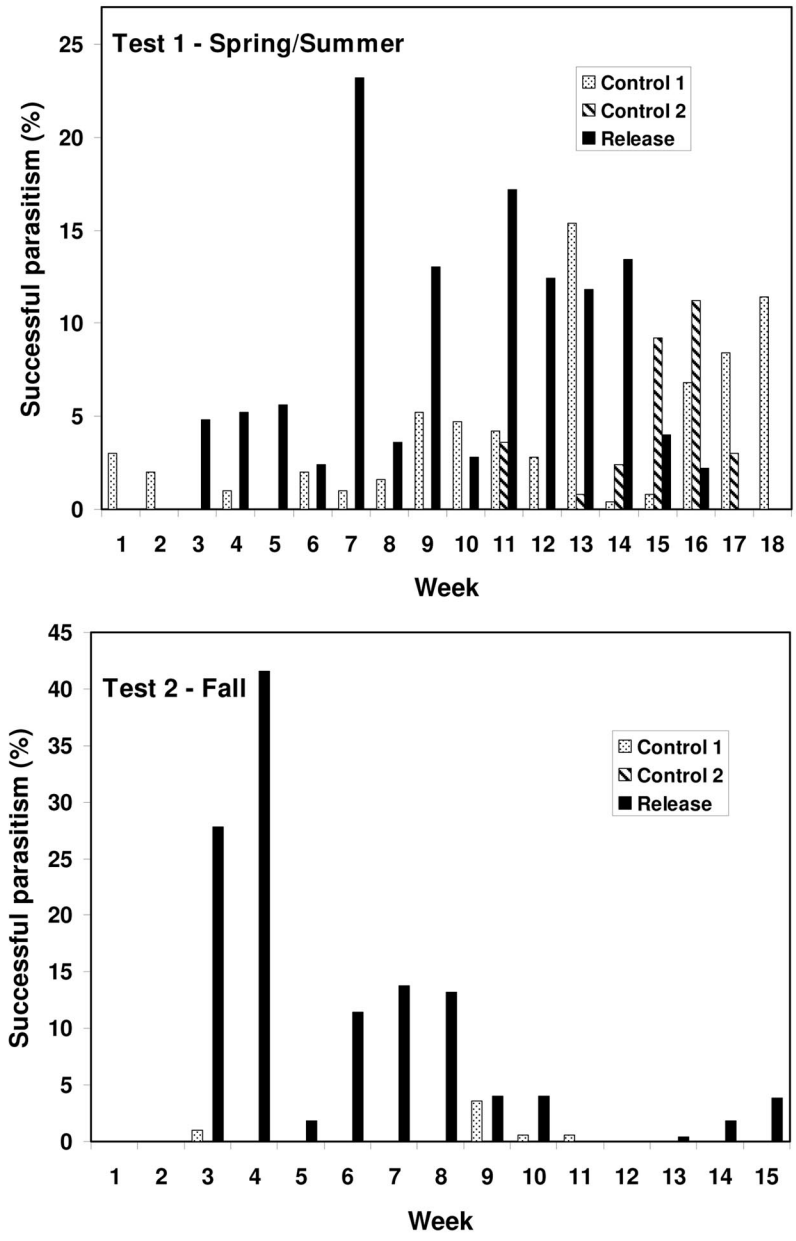

Fig. 3. Weekly successful parasitism (hosts from which adult parasitoids emerged) of sentinel pupae in control pullet houses and in houses where *M. raptorellus* and *S. cameroni* were released during the first 12 wk of the flock growth cycle.

First, the number of female *M. raptorellus* released per week averaged ≈2.5 times the number of *S. cameroni* released. Second, our use of sentinel bags as an estimate of parasitoid activity would have been expected to result in overestimation of *Muscidifurax* spp. activity and underestimation of *Spalangia* spp. because this sampling method tends to favor species that search for pupae near the manure surface (Petersen and Watson 1992, Geden 2002). We used sentinel pupae because the alternative method of collecting wild pupae makes it difficult to assess host mortality and sample known locations in a consistent manner (see Kaufman 2001b for a recent discussion on biases in various parasitoid sampling methods). Tobin and Pitts (1999) found that *M. raptorellus* only moved a short distance from the release point in high-rise poultry houses. It is possible that the 10 release stations per house that we used did not provide sufficient distribution for this species.

Muscidifurax raptorellus is difficult to distinguish from solitary members of the genus, and proper identification

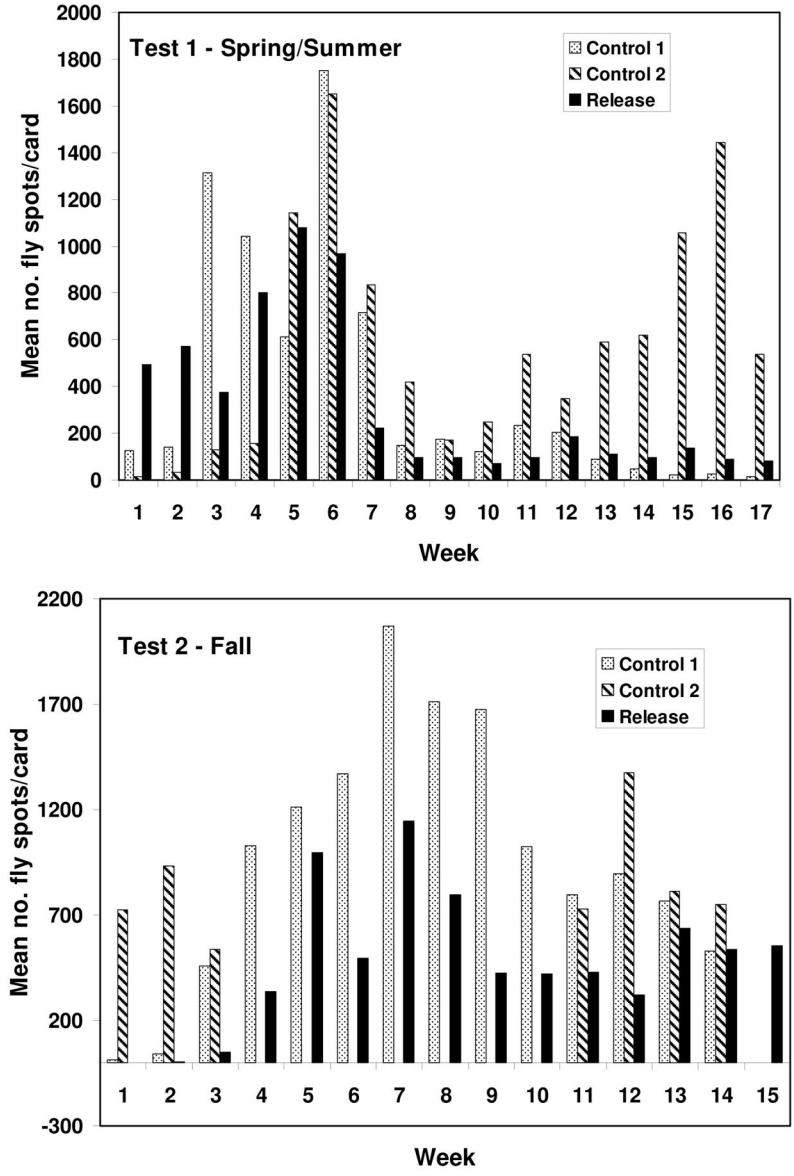

Fig. 4. Weekly fly abundance (measured by spot cards) in control pullet houses and in houses where *M. raptorellus* and *S. cameroni* were released during the first 12 wk of the flock growth cycle.

requires close examination of the wings (Kogan and Legner 1970). To facilitate the processing of samples, we assigned all cases of gregarious *Muscidifurax* parasitism to *M. raptorellus* and all solitary parasitism to *M. raptor*, following the method used by others (Floate et al. 2000, Kaufman et al. 2001a, b). However, examination of the pupae used in the releases indicated that ≈9% of parasitism by *M. raptorellus* resulted in the emergence of a single parasitoid. Similarly, Lysyk (2004) observed solitary emergence of this species from 19 and 14% of house fly and stable pupae, respectively. Although convenient, this method seems to result in a substantial underreporting of parasitism by *M. raptorellus.*

Rates of fly pupal mortality in the release houses in this study were two to five times higher, at 40.2 and 45.6%, than in the control houses. Rates of successful parasitism, however, were only ≈8% in the release houses, indicating a high rate of parasitoid-induced mortality. Tobin and Pitts (1999) observed ≈10% parasitism by *M. raptorellus* in Pennsylvania poultry houses where this species was released at rates considerably higher than were used in our study. Similarly, Kaufman et al. (2001a) observed ≈1–6% parasitism after releases of *M. raptorellus* in New York poultry houses using a release rate ~10 times higher (four parasitoids/bird) than we used. When this rate

Table 3. Relative abundance of parasitoids on control pullet farms and on farms where releases of *S. cameroni* and *M. raptorellus* were made during the first 12 wk after cleanout and new bird placement

Treatment	Total	Parasitized pupae						
		Percent of pupae parasitized by species						
		S. cameroni	*M. raptorellus*	*S.c. + M.rls*[a]	*M. raptor*	*S. endius*	*Nasonia vitripennis*	*S. nigroaenea*
Test 1—spring/summer								
Control 1	330	38.6	1.0	40.5b	28.1	29.7	1.7	0.0
Control 2	151	47.6	0.0	38.3b	6.3	47.6	0.0	7.7
Release	627	62.9	11.4	74.3a	14.7	10.6	0.4	0.0
Test 2—fall								
Control 1	60	51.1	0.0	51.1b	11.1	26.7	11.1	0.0
Control 2	0	—	—	—	—	—	—	—
Release	623	44.9	28.9	73.8a	23.4	3.0	0.0	0.0

Means within the *S.c + M.rls* column within tests followed by the same letter are not significantly different at $P = 0.05$ (Proc GLM of SAS).
[a] Sum of the relative abundance of *S. cameroni* (*S.c.*) and *M. raptorellus* (*M. rls*).

was increased to 13 parsaitoids/bird in a subsequent study, these authors observed >77% host mortality and >48% parasitism (Kaufman et al. 2001b).

Fly production in Florida pullet houses is typically very high because the thorough cleanout between flocks and short production cycle does not allow sufficient time for the establishment of robust populations of predators and parasitoids. For example, mean parasitism in our control houses only ranged from 0 to 3.9%. Moreover, the manure in these houses is often very wet during hot weather because of increased water consumption by the birds. In this study, releases of these two parasitoids significantly reduced fly populations compared with controls, but fly abundance was still above the 100 spots/card/wk that is generally considered an acceptable level. Additional work with higher release rates or integration of other control components such as fly baits is needed to determine the practicality of parasitoid use in this difficult production system.

Acknowledgments

The authors thank H. Brown and S. Wren for assisting with field work and counting spot cards.

References Cited

Andress, E. R., and J. B. Campbell. 1994. Inundative releases of pteromalid parasitoids (Hymenoptera: Pteromalidae) for the control of stable flies, *Stomoxys calcitrans* (L.) (Diptera: Muscidae) at confined cattle installations in west central Nebraska. J. Econ. Entomol. 87: 714–722.

Crespo, D. C., R. E. Lecuona, and J. A. Hogsette. 1998. Biological control: an important component in integrated management of *Musca domestica* (Diptera: Muscidae) in caged-layer poultry houses in Buenos Aires, Argentina. Biol. Control. 13: 16–24.

Floate, K. D., P. Coghlin, and G.A.P. Gibson. 2000. Dispersal of the filth fly parasitoid *Muscidifurax raptorellus* (Hymenoptera: Pteromalidae) following mass releases in cattle confinements. Biol. Control. 18: 172–178.

Geden, C. J. 1996. Modeling host attacks and progeny production of *Spalangia gemina*, *S. cameroni* and *Muscidifurax raptor* (Hymenoptera: Pteromalidae) at constant and variable temperatures. Biol. Control. 7: 172–178.

Geden, C. J. 1997. Development models of the filth fly parasitoids *Spalangia gemina*, S. cameroni, and *Muscidifurax raptor* (Hymenoptera: Pteromalidae) under constant and variable temperatures. Biol. Control. 9: 185–192.

Geden, C. J. 1999. Host location by house fly parasitoids in poultry manure at different moisture levels and host densities. Environ. Entomol. 28: 755–760.

Geden, C. J. 2002. Effect of habitat depth on host location by five species of parasitoids (Hymenoptera: Pteromalidae, Chalcididae) of house flies (Diptera: Muscidae) in three types of substrates. Environ. Entomol. 31: 411–417.

Geden, C. J., D. C. Steinkraus, R. W. Miller, and D. A. Rutz. 1992. Suppression of house flies on New York and Maryland dairies using *Muscidifurax raptor* in an integrated management program. Environ. Entomol. 21: 1419–1426.

Kaufman, P. E., S. J. Long, D. A. Rutz, and J. K Waldron. 2001a. Parasitism rates of *Muscidifurax raptorellus* and *Nasonia vitripennis* (Hymenoptera: Pteromalidae) after individual and paired releases in New York poultry facilities. J. Econ. Entomol. 94: 593–598.

Kaufman, P. E., S. J. Long, and R. A. Rutz. 2001b. Impact of exposure length and pupal source on *Muscidifurax raptorellus* and *Nasonia vitripennis* (Hymenoptera: Pteromalidae) parasitism in a New York poultry facility. J. Econ. Entomol. 94: 998–1003.

King, B. H. 1997. Effects of age and burial of house fly (Diptera: Muscidae) pupae on parasitism by *Spalangia cameroni* and *Muscidifurax raptor* (Hymenoptera: Pteromaildae). Environ. Entomol. 26: 410–415.

Kogan, M., and E. F. Legner. 1970. A biosystematic revision of the genus *Muscidifurax* (Hymenoptera: Pteromalidae) with descriptions of four new species. Can. Entomol. 102: 1268–1290.

Lysyk, T. J. 2001. Relationships between temperature and life history parameters of *Muscidifurax raptorellus* (Hymenoptera: Pteromalidae). Environ. Entomol. 30: 982–992.

Lysyk, T. J. 2004. Host mortality and progeny production by solitary and gregarious parasitoids (Hymenopter: Pteromlidae) attacking *Musca domestica* and *Stomoxys calcitrans* (Diptera: Muscidae) at varying host densities. Enrviron. Entomol. 33: 328–339.

McKay, T., and T. D. Galloway. 1999. Survey and release of parasitoids (Hymenoptera) attacking house and stable flies (Diptera: Muscidae) in dairy operations. Can. Entomol. 131: 743–756.

Meyer, J. A.B. A. Mullens, T. L. Cyr, and C. Stokes. 1990. Commercial and naturally occurring fly parasitoids (Hymenoptera:Pteromalidae) as biological control agents of stable flies and house flies (Diptera: Muscidae) on California dairies. J. Econ. Entomol. 83: 799–806.

Morgan, P. B., H. Hoyer, and R. S. Patterson. 1989. Life history of *Spalangia cameroni* (Hymenoptera: Pteromalidae), a microhymenopteran pupal parasite of Muscoid flies (Diptera: Muscidae). J. Kansas Entomol. Soc. 62: 381–386.

Morgan, P. B., and R. S. Patterson. 1990. Efficiency of target formulations of pesticides plus augmentative releases of *Spalangia endius* Walker (Hymenoptera: Pteromalidae) to suppress populations of *Musca domestica* L. (Diptera: Muscidae) at poultry ranches in the southeastern United States, pp. 69–78. *In:* D. A. Rutz and R. S. Patterson (eds.). Biocontrol of arthropods affecting livestock and poultry, Westview, Boulder, CO.

Petersen, J. J., and J. K. Cawthra. 1995. Release of a gregarious *Muscidifurax* species (Hymenoptera: Pteromalidae) for the control of filth flies associated with confined beef cattle. Biol. Control. 5: 279–284.

Petersen, J. J., and D. W. Watson. 1992. Comparison of sentinel and naturally occurring fly pupae to measure field parasitism by pteromalid parasitoids (Hymenoptera). Biol. Control. 2: 224–248.

Rueda, L. M., and R. C. Axtell. 1985. Effect of depth of house fly pupae in poultry manure on parasitism by six species of Pteromalidae (Hymenoptera). J. Entomol. Sci. 20: 444–449.

Rutz, D. A., and R. C. Axtell. 1979. Sustained releases of *Muscidifurax raptor* (Hymenoptera: Pteromalidae) for house fly (*Musca domestica* L.) control in two types of caged-layer houses. Environ. Entomol. 8: 1105–1110.

Rutz, D. A., and R. S. Patterson (eds.). 1990. Biocontrol of arthropods affecting livestock and poultry. Westview, Boulder, CO.

SAS Institute. 1995. SAS users guide: statistics. SAS Institute, Cary, NC.

Skovgard, H., and G. Nachman. 2004. Biological control of house flies *Musca domestica* and stable flies *Stomoxys calcitrans* (Diptera: Muscidae) by means of inundative releases of *Spalangia cameroni* (Hymenoptera: Pteromalidae). Bull. Entomol. Res. 94: 555–567.

Tobin, P. C., and C. W. Pitts. 1999. Dispersal of *Muscidifurax raptorellus* Kogan and Legner (Hymenoptera: Pteromalidae) in a high rise poultry facility. Biol. Control. 16: 68–72.

Weinzierl, R. A., and C. J. Jones. 1998. Releases of *Spalangia nigroaenea* and *Muscidifurax zaraptor* (Hymenoptera: Pteromalidae) increase rates of parasitism and total mortality of stable fly and house fly (Diptera: Muscidae) pupae in Illinois cattle feedlots. J. Econ. Entomol. 91: 1114–1121.

Received for publication 10 February 2005; accepted 6 September 2005.